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0	0	0	0	0	LINE n−2
1/32	1/16	1/16	1/16	1/32	LINE n−1
0	0	1/2	0	0	LINE n
1/32	1/16	1/16	1/16	1/32	LINE n+1
0	0	0	0	0	LINE n+2

(57) Abstract

Conversion of a computer graphics signal into an interlaced TV video signal using conventional signal processing can give rise to considerable flicker in the resulting display where there are highly contrasting odd and even fields. With the inventive signal processing means the output for each line of the video signal is created by summing a reduced intensity version of the current field and the filtered versions of the immediately adjacent field lines. The effect of applying the filter of a preferred processing means to a single pixel signal in line n is shown in the filter characteristic of the figure, the filter comprising a low-pass filter means which derives a low frequency Fourier component of the adjacent field lines that represents their brightness but not the fine details. This enables fine details to be preserved whilst substantially reducing flicker in the display.

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PROCESSING OF SIGNALS FOR INTERLACED DISPLAY

This invention relates to a signal processing means for processing a signal which is suitable for use on an interlaced display device, such as a low-cost monitor, a television set or to record as a recorded TV video signal. The signal will often contain fine detail, such as that which is present in a computer graphics signal.

The invention is concerned with reducing flicker in an interlaced display.

It is known for computers to be provided with an output which is intended for connection to a TV to enable the TV to display computer graphics. For example, some display cards and video games can generate non-interlaced signals for TV sets with about half the scan lines of the interlaced TV standard. This however results in reduced vertical resolution. Some others generate interlaced computer graphics signal with the same number of scan lines but they suffer from flicker.

Converters are known which have an input to receive a computer graphics signal having a higher horizontal scanning rate, and an output for providing an output signal at a low horizontal scanning rate suitable for use as a TV video signal, the low rate being exactly half the high rate. The inventive signal processing means may be used in conjunction with such a converter, or the signal processing means may be incorporated in the converter.

The computer graphics output signal is often generated as a non-interlaced signal at twice the usual horizontal scanning rate of a TV standard having the same number of total scan lines. In that case the signal processing means can be arranged to store in memory several lines of the computer graphics output for processing, and then to output the processed line at substantially half the scanning rate of the graphics signal in interlaced mode, to provide the TV

video signal.

The synchronising pulses required for television are generally different from those incorporated in the computer graphics signal but are related in timing. The signal processing means preferably comprises conversion means arranged to generate television synchronising pulses which are configured according to the appropriate standards, such as those employed for NTSC, SECAM and PAL.

It should be appreciated that the TV video signal will normally contain both luminance and chrominance signals, for a colour display. The synchronising pulses and the red, green and blue computer graphics signals can be mixed to give the required TV signals by using standard integrated circuits.

We have appreciated that the flicker in normal interlaced signal generated by computer or converted from computer output is due to the possibility of having very different video signals for the odd and even fields. For most real-life images normally displayed on TV, brightness and colour transitions are not abrupt; the odd and even fields are showing more or less the same information. The scanning spot of TVs is usually thicker than the spacing between lines. Therefore a patch of colour appears to be showing up every 1/50 or 1/60 of a second for PAL and NTSC standard. This is fast enough to give an impression of stability. However, the graphics and characters of a computer output can be only one line thin. In the extreme case of an area with alternate black and white horizontal lines, one field will be showing all white lines in that area and the other field will be showing all black lines. That area is then lit up every 1/25 or 1/30 of a second. This is slow enough for the eye to detect.

Anti-flicker filters have been designed that balance the brightness of the odd and even fields by applying a digital filter on pixels along the direction perpendicular to the scanline direction. For normal TVs, scanlines are horizontal. Hence, the anti-flicker filters are applied vertically. One method, known from prior art (see filter shape 1 in Figure 4) adds half the brightness of the pixel above with half the brightness of the current pixel. In this case, each bright pixel or horizontal line segment in a dark background (or dark pixel or horizontal line segment in a bright background), appears to move up and down by one pixel at the field frequency. For long horizontal lines, which are quite common in graphical user interfaces, the collective movement will be quite noticeable. A better method, also known from prior art, (see filter shape 2 in Figure 5) adds ¼ the brightness of the pixel above and below to avoid this effect for long horizontal lines. Any such anti-flicker filter based on a one-dimensional digital filter has to strike a trade-off between vertical resolution and the degree of flicker suppression. A low-pass traditional two-dimensional filter can also reduce flicker at the cost of resolution. A two-dimensional filter in accordance with the invention preserves resolution in most cases while suppressing flicker by applying low-pass filtering to pixels of the other field (odd or even) before mixing with pixels of the current field (even or odd).

According to the invention a signal processing means, utilising either software or hardware, has an input to receive an image with fine detail and an output for providing an image suitable for use as an interlaced video signal, the signal processing means being arranged to generate the output for a current line by adding a component produced from the graphics signal of adjacent lines to the current line, the component being produced by subjecting the graphics signal of the adjacent lines to a low-pass filter means, before being added to the current line.

Such a signal processing means is capable of substantially reducing flicker in the display of an interlaced video signal yet preserving fine details from the graphics signal.

The total weight of the low-passed signal is preferably arranged to be no greater than that of the weight of the centre pixel after processing, such that detail in the graphics signal used in one field (odd or even) of the interlaced output signal is not masked by the intensity of the signal contributed from the other field (even or odd respectively).

Thus, output for each field, say the odd field, lines of the video signal are created by summing a reduced intensity version of the current field which is the odd field and the filtered versions of the immediately adjacent even field lines, the filtering means comprising a low-pass filter means which derives a low frequency Fourier component of the even field lines that represent the brightness of the even field lines but not the fine details.

Embodiments of the invention will now be described, by way of example only, with reference to the accompanying Figures 1-3, in which:

Figure 1 is a display of a graphics signal prior to processing by a signal processing means in accordance with the invention,

Figure 2 is a display of the graphics signal used for Figure 1, but after subjecting the graphics signal to a signal processing means in accordance with the invention and which incorporates a filter having the characteristics of Figure 3,

Figure 3 is a chart showing a filter characteristic, and the effect of applying the filter to a single pixel signal in line n,

Prior art filter characteristics have been described above with reference to Figures 4 and 5 in which:

Figure 4 is a chart showing a simple filter characteristic, and

Figure 5 is a chart showing an improved simple filter characteristic.

In order to provide a stable image of the TV video signal, the interlaced scan-lines of the interlaced video signal are generated by addition of a low-passed version of the line above and below of the unprocessed graphics signal to the current line of the graphics signal.

The addition of signal from the odd field to the even field and vice versa ensures that the brightness in any region is approximately the same in both fields. Hence, the screen appears to be refreshing at the field rate (50Hz for PAL and 60Hz for NTSC) rather than the frame rate (25Hz for PAL and 30Hz for NTSC) and is more stable. However, since only a low-passed version of the other field is present, details from the other field will not interfere with that of the current field.

The filtering of the signal can be done either by software or hardware. If done by software, a plain video converter which performs direct RGB to composite signal conversion can be used to get a stable and sharp image. If done by hardware, it can generate stable and sharp output on a TV even for thin characters.

Low cost analogue filters implemented with discrete components and linear integrated circuits can be used to low-pass and mix the simultaneously generated video signal in the odd and even field. If the pixel data in digital format is taken at video rate, digital filter integrated circuits can be employed to implement the filter before digital to analogue conversion.

Figure 3 shows one suitable filter characteristic. The rectangular cells represent individual pixels, and the values inside represent the weights of the filter for the various neighbouring pixels. It can be implemented by software or digital filter easily.

The filter of Figure 3 gives half weight of the unprocessed pixel intensity to the centre pixel, and the remaining half of the weight is distributed as a modulation over a short segment in each of the lines above and below of the TV video signal. Put another way, a single bright pixel will appear as a pixel of half the maximum brightness and as two dispersed line segments of low brightness, in the lines above and below. What is seen on the screen is still a sharp pixel since the two dispersed dim segments are less noticeable. Since the total brightness this pixel generates in the two fields is the same over a small region covering the span of the filter, it is observed as flashing at the field rate rather than the frame rate. Without this filtering, it is observed as flashing at the frame rate because the pixel is displayed in one field but not the other.

Reference 1 of Figure 1 shows the extreme case of alternating black and white lines which will flicker seriously without the filtering.

As shown at 2 and 3 in Figure 2, shades around a letter or character produced by the filtering balance the brightness between odd and even lines to significantly reduce flicker, whilst preserving fine details.

If part of an image consists of alternating black and white horizontal lines substantially longer than a few pixels, stability of the image is obtained using the exemplary filter at the cost of reducing this area into a uniform grey except near the ends of the lines, as shown at 4 in Figure 2. The uniform grey appears not to flicker.

For some characters, therefore, some detail can be lost, as shown at 5 in Figure 2.

In a modification, the weight of the centre pixel could be increased slightly above $\frac{1}{2}$ to reveal the detail at the cost of some flicker.

The range from $\frac{1}{2}$ to 1 for the centre pixel represents maximum flicker suppression to no processing and an in-between value represents a trade-off. From the information point of view, there is no interesting detail in an area consisting of a regular alternation of black and white lines. Hence it does not generally matter even if that detail is lost so that in general a fixed filter can be used, although there may be circumstances where a variable filter may be desirable.

CLAIMS

1. A signal processing means, utilising either software or hardware, having an input to receive an image with fine detail and an output for providing an image suitable for use as an interlaced video signal characterised in that the signal processing means is arranged to generate the output for a current line by adding a component produced from the graphics signal of adjacent lines to the current line, the component being produced by subjecting the graphics signal of the adjacent lines to a low-pass filter means, before being added to the current line.

2. A signal processing means as claimed in claim 1, characterised by conversion means arranged to generate television synchronising pulses according to an appropriate television standard.

3. A signal processing means as claimed in claim 1 or claim 2, characterised in that the output for each field line of the video signal is created by summing a reduced intensity version of the current field line and the filtered versions of the immediately adjacent field lines, the filtering means comprising a low-pass filter means which derives a low frequency Fourier component of said adjacent field lines that represents their brightness but not their fine details.

4. A signal processing means as claimed in any one of the preceding claims, characterised in that it gives part of the weight of the unprocessed intensity of a pixel in one line to that pixel, the remaining part of the weight being distributed as a modulation over a short segment in each of the immediately adjacent lines of the video signal on either side of said one line.

5. A signal processing means as claimed in claim 4, characterised in that substantially half of the weight of the unprocessed pixel intensity is given to the centre pixel.

6. A signal processing means as claimed in claim 4, characterised in that more than substantially half of the weight of the unprocessed pixel intensity is given to the centre pixel.

7. A signal processing means as claimed in any one of claims 4 to 6, characterised in that the part of the weight of the unprocessed pixel intensity given to the centre pixel can be varied.

8. A signal processing means as claimed in any one of the preceding claims, characterised by low cost analogue filters implemented with discrete components and linear integrated circuits for low-passing and mixing a simultaneously generated video signal in the odd and even fields.

9. A signal processing means as claimed in any one of claims 1 to 7, in which pixel data in digital format is taken at video rate, characterised by digital filter integrated circuits for implementing the filter before digital to analogue conversion.

10. A signal processing means as claimed in any one of claims 1 to 7, characterised in that filtering of the signal is performed by software, a plain video converter which performs direct RGB to composite signal conversion being used to get a stable and sharp image.

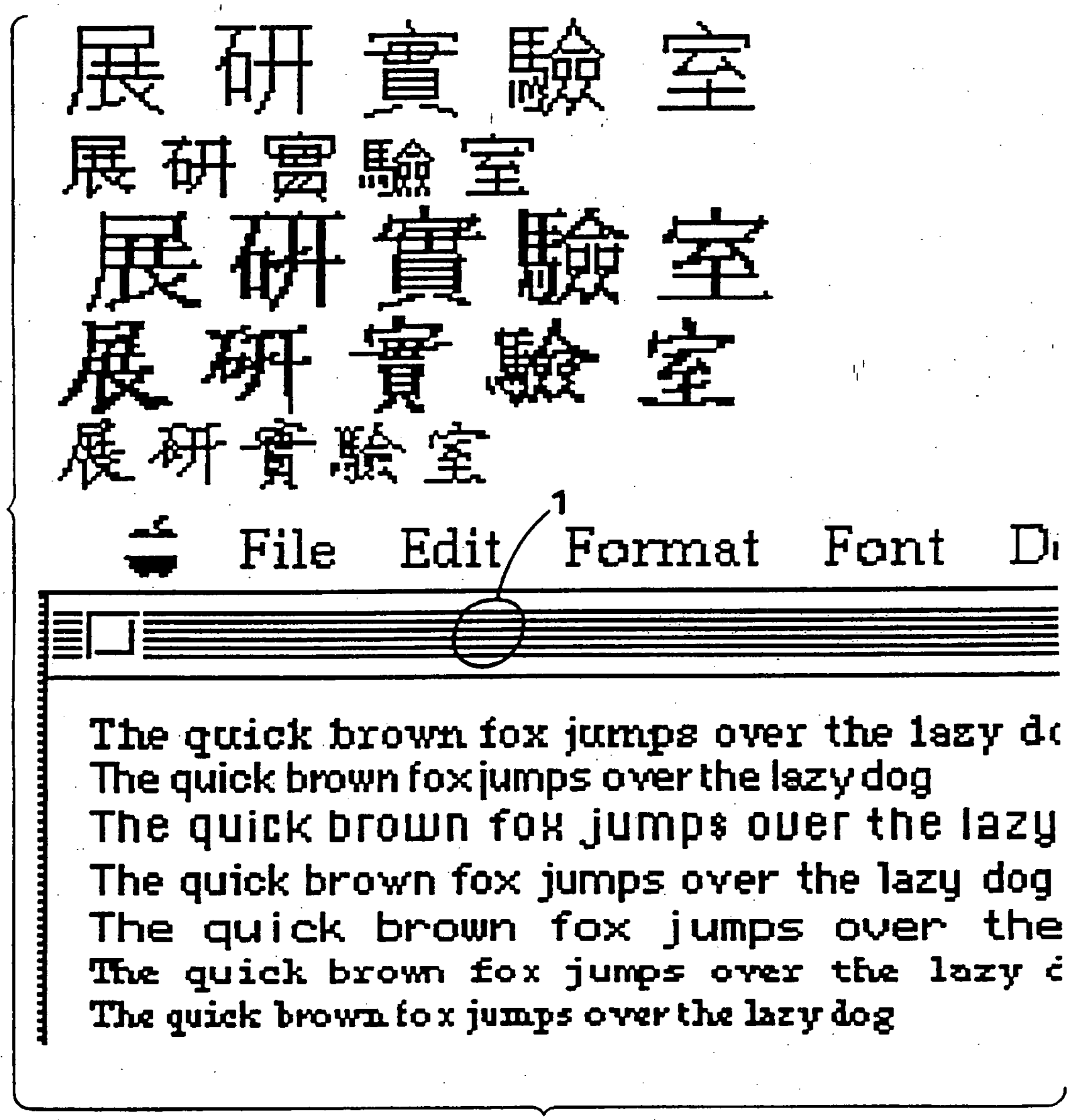
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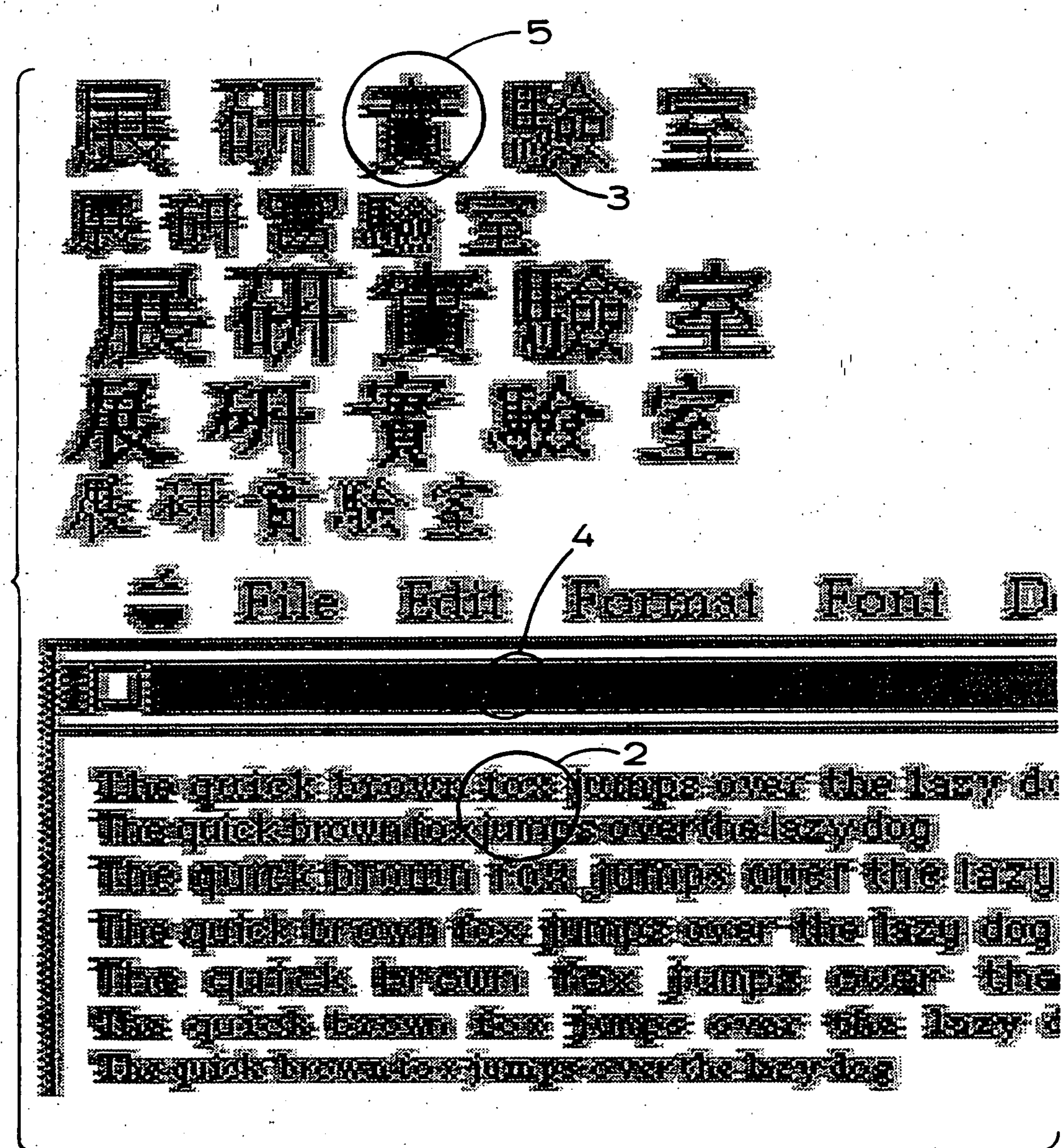
FIG.1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The quick brown fox jumps over the lazy dog

FIG. 2

0	0	0	0	0	LINE n−2
1/32	1/16	1/16	1/16	1/32	LINE n−1
0	0	1/2	0	0	LINE n
1/32	1/16	1/16	1/16	1/32	LINE n+1
0	0	0	0	0	LINE n+2

FIG. 3.

filter shape1
PRIOR ART

1/2
1/2

FIG. 4.

filter shape 2
PRIOR ART

1/4
1/2
1/4

FIG. 5.

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 93/02308

A. CLASSIFICATION OF SUBJECT MATTER
IPC 5 G09G1/16

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 5 G09G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US,A,5 097 257 (ELIZABETH A. CLOUGH) 7 January 1992 see abstract; figures 1-5 see column 4, line 49 - column 7, line 60 ---	1-10
A	US,A,4 843 380 (DAVID OAKLEY) 27 June 1989 see abstract; figures 7-19 ---	1,3-7,9
A	EP,A,0 492 696 (N.V. PHILIPS' GLOEILAMPENFABRIEKEN) 1 July 1992 see column 7, line 50 - column 9, line 15 ---	1,2,8
A	WO,A,90 07767 (APPLE COMPUTER, INC) 12 July 1990 see abstract; figure 2 -----	1-10

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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1

Date of the actual completion of the international search	Date of mailing of the international search report
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/GB 93/02308

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